TITLE

DEVICE FOR ELIMINATION OF INCOMBUSTIBLE PARTICLES FROM GASES.

DESCRIPTION

Technical field

The present invention relates to a device for the elimination of particles pr4esent in smoke and exhaust gases, in particular diesel engine exhaust gases and particles related to the combustion of wood fuel and ventilation air.

The object of the present invention is to obtain a device for elimination/reduction of the amount of solid particles in smole and exhaust gases in order to thereby reduce the environmental risks, in particular for those being present in the neighbourhood, i.e., are present close to a major road having a high traffic load or are present in the neighbourhood of frequent wood heating.

Background of the invention

Today wood heating exists to a large extent in the form of combustion of chips, pellets and larger blocks thanks to the fact that it is counted for as a renewable energy source, a bio fuel, as the carbon dioxide produced during combustion will return to nature and be assimilated by the growing plants.

At industrial wood heating there are considerable requirements on smoke gas purification, which means very small emissions, but at small scale wood heating the combuston is very much done "by instinct" and quite often an incomplete combustion will occur at nights as one reduces the admission of air in order to keep heat as long as possible. It is not pleasant to wake up in chilly or cool rooms and walk over to the heater on cool floors. Insufficient admission of combustion air will, however, lead to insufficient combustion, quite often a pyrolysis, and the production of carbon monoxide which is an extremely poisonous gas as it blocks the transport of oxygen in the blood by occupying the oxygen carrying sites in haemoglobin in the blood.

Small scale wood heating means emission of moisture in the form of steam contained in the wood (normally 25% or more) but also emission of large amounts of particles, emissions of tar or more heavy hydrocarbons, such as polyaromathic compounds (PAH), NO_x, hydrocarbons, such as methane, ethanol, benzene, and others, aldehydes, such as formaldehyde, as well as carbon monoxide and carbon dioxide. The correlation between

different substances in the exhaust of small scale wood heating is hard to determine due to the complex chemical reactions which occur at the combustion.

It is, however, clear that a moist fuel provides increasing emissions with the excveption of NO_x, where moist wood gives 3 times higher amounts of CO, 5-10 times higher amounts of tar, 10 times higher amounts of light hydrocarbons and 30 times higher amounts of PAH.

When it comes to the emission of carbon monoxide it is important that a complete combustion occurs, which means that at least stoichiometric amount of air (4.7 normal cubic meters per kg dry wood) but in most cases a considerable excess, up to 100% to obtain a complete combustion depending on incomplete in-mix of air and thereby oxygen to the fire hearth.

In the mid 1980ties ceramic lined, in particular wood furnaces, were introduced in Sweden to obtain an improved combustion and improved assimilation of the energy content of the fuel. In spite of this, 60% of the emissions of PAH in Sweden are regarded as derived from wood heating and this is our foremost sole pollution source. Swedish authorities has invested SEK 30 millions to investigate the impact on the health by these emissions.

SE-C-513 391 discloses a device for complete cobustion of solid fuels and comprises two combustion chambers joined together, of which one is a combustion chamber for drying and gasification of the fuel and the second one is a final combustion chamber for combustion of the gasified fuel and whereby a ceramic filter is arranged as a partition wall between the chambers, which filter allows the gasified fuelt to pass through but blocks remaining solid substance to pass into the final combustion chamber and whereby the combustion gas is forced to pass the ceramic filter whereby the combustion temperature is raised to a suitable combustion temperature. This device is meant to replace a conventional furnace.

NO-C-131,325 relates to a device for separating solid particles from a gas stream by direct the gas from a source to a mixing chamber where a mixture of steam and atomized liquid droplets are introduced under such conditions that the liquid droplets are accelerated to a speed of at least 60 m/s over the inlet speed, whereby solid particles are caught by the liquid droplets, whereby a subpressure is obtained in the mixing chamber. The invention is thereby related to a ration between steam and atomized droplets.

US-A-6,019,819 relates to a device catching a condensate, which condensate contains oil and other hydrocarbons from food processing, such as French frying potatoes.

WO 99/56854 relates to a process for separating particles from a flow of hot gas whereby the relative humidity is primarily increased to almost saturation, then gas and particles are cooled adiabatically so that water condenses upon the particles whereupon the particle containing water is separated off.

EP-A-0 110 438 relates to a process and a device for purification of particle containing gas by means of condensation of water onto the particles in the gas and a separation of water droplets comprising particles.

However, there is a great demand for a completion of existing furnaces by means of a final combustion part to be able to reduce emissions of toxic gases and compounds, as well as there is a need for being able to eliminate particles on one hand from small scale wood heating, on the other hand from diesel engines, either mobile or stationary.

Nothing in the prior art discussed above can provide this.

Summary of the present invention

The present invention relates to a device for the elimination of particles from smoke and exhaust gases and is characterized by
comprising a first chamber having an inlet for smoke or exhaust gas,
further comprising a heatable combustion zone,
comprising a second chamber having an inlet from said first chamber for said gas, and
comprising an outlet for collection of particles.

In a preferred embodiment of the invention the device further comprises means for provide turbulence of said gas.

In a preferred embodiment of the invention the device further comprises means for adding atomized liquid, preferably water.

In a preferred embodiment of the invention the device further comprises an outlet for particle containing condensate.

In another preferred embodiment of the invention the device further comprises a second inlet into the first chamber for the addition of combustion aiding gas.

In a further preferred embodiment of the invention the device further comprises a heat exchanger arranged in the second chamber to heat exchange between gas and liquid.

In another preferred embodiment of the invention the device further comprises a heat exchanger arranged in the outlet of the second chamber for heat exchange between gas and gas.

In a another preferred embodiment of the invention the device further comprises a means for the addition of energy to said heatable combustion zone.

In a further preferred embodiment of the invention the device comprises a means for atomizing a liquid.

In another preferred embodiment of the invention the device comprises a means for transfer of liquid into vapour form.

In another preferred embodiment of the invention the device for separation of a condensate comprises a rotatable helical centrifuge.

In a further preferred embodiment of the invention the device comprises a gas outlet placed in the outlet of the second chamber, in which gas outlet there is an evacuation fan to obtain a subpressure in said first and second chambers for the driving of said helical centrifuge.

In a further preferred embodiment of the invention, in particular for the purification of diesel exhaust gases, the device comprises a tubular chamber having an inlet part, which chamber is provided with a gas permeable sock, which allows passage of a substantially particle free gas to a second chamber,
that it comprises a brake plane arranged in the first chamber at the end facing away from the inlet part to catch particles and in connection to said brake plane there is a combustion zone arranged and
that it comprises an outlet for the elimination of collected, non-combusted particles.

In a further preferred embodiment of the invention the device comprises a temperature influenced opening arranged in the inlet part to obtain a predetermined high smoke gas

flow in the first chamber to obtain a safe catch of the particles at the brake plane of the device.

In a further preferred embodiment of the invention the device catches and makes the particles subject to a combustion, said particles having a particle size less than 1 µm, preferably less than 0,5 µm, more preferably less than 0,3 µm, further more preferably less than 0,2 µm.

Detailed description of the present invention

The present invention will now be described in more detail with reference to the accompanying drawing, however, without being restricted to this or the embodiment being related thereto, in which drawing

FIG. 1 shows a schematic cross-sectional view of a device according to the invention,

FIG. 2 shows a graph over particle size versus the number of particles at wood heating in a pellet furnace,

FIG. 3 shows the particel size distribution after smoke gas purification in a device according to FIG. 1

FIG. 4 shows an electron microscopy image of a smoke gas particle prior to the purification step,

FIG, 5 shows an electron microscopy image of an agglomerated particle obtained after passage of a smoke gas purification according to FIG. 1,

FIG. 6 shows a schematic embodiment of a device for catching and eliminating particles from a diesel engine,

FIG. 7 shows a second schematic embodiment of a device for catching and eliminating particles from a diesel engie,

FIG. 8 shows an embodiment of a device for catching and eliminating particles from a diesel engine according to FIG. 6,

FIG. 9 shows rate distribution in exhaust gases in a device according to FIG. 8, and

FIG. 10 shows a part device for the adjustment of gas flow speed in an exhaust tube from a diesel engine (not shown).

In the device according to FIG. 1 there is a first chamber 1 having an inlet 3 from a combustion plant, such as a wood heating furnace (not shown). In connection to the inlet 3 there is an air inlet 4, as well, to obtain a forced addition of air. In the first chamber there is a fan 5, as well, to be able to perform a complete mixing of incoming air from the air inlet 4 and smoke gas from the inlet 3.

Above the first chamber 1, there is a second chamber 2 being arranged, which is connected to the first chamber 1 via a heatable combustion zone 6, which can be a filter containing an electrical heating, or be provided with heat from infra heaters 7 arranged in the first chamber. Above the combustion zone 6 a fine mesh net 8 is provided across the cross-section of the section chamber 2. Above this net 8 there is a water inlet 9 arranged through which water and/or steam can be added to the formation of cloud of atomized water above the net 8. In the upper part of the second chamber 2 there is a heat exchanger for heat exchange between hot gas and water, i.e., emittance of heat to water, being part of the water of a heating system of a house in a building either as hot tap water or as water carried heat to radiators.

The second chamber 2 is provided with a smoke gas outlet 17 being connected to a second heat exchanger 10 for heat exchange between gas and air. To the gas part of this heat exchanger 10 there is a condenser 11 being connected for deviation of any condensate from the gas.

In the condenser 11 there is suitably a helical centrifuge 16 being arranged.

In a smoke gas outlet 12 a fan 13 is arranged to draw gas/air through the system of first 1 and second 2 chambers. The second heat exchanger 10 is provided with an inlet 14 and an outlet 15 for through going air.The outlet 15 can be connected to the ventilation system of a building while the inlet 14 suitably being connected directly to a fresh air inlet in a wall (not shown).

The system works in such a way that hot smoke gases, 850°C or more, having their contents of particles and volatile light and heavy hydrocarbons are introduced into the inlet 3 of the first chamber 1. There the smoke gases are mixed with incoming air through the air inlet 4 by means of the fan 5. The smoke gases so blended will then pass the combustion zone 6 in which, still combustible gases, including CO (carbon monoxide) are combusted to the formation of CO_2 and water. The water is added simultaneously through the water inlet 9 which can be connected to a water line or to the condenser 11, which water in close contact with the hot net 8 is vaporized (atomized), whereby the aprticles and heavy gases are caught by the water and are carried further on past the first hea exchanger 9, where a heat exchange will take place against water. The, somewhat cooled smoke gases, 90-100°C, are then transported to the outlet of the second chamber and to the second heat exchanger 10 where a further cooling down will take place by means of heat exchange against air. In particular in this later part the water present in the smoke gases will condense and be collected in the

condenser 11 having its outlet 21 together with the particles which have been carried by the smoke gases from the primary combustion in the wood heating furnace, not shown.

By means of the fan 13 arranged in the smoke gas exhaust 12 the smoke gases will be drawn all the time through the two chamber and pass the two heat exchangers. This subpressure will also allow the helical centrifuge 16 to self-rotate and provides a longer transportation way of the outgoing smoke gas to provide an increased condensation of ingoing water. The helical centrifuge is a helical screw provided in a tight shaft, which shaft is journalled in a bearing in a centrifuge housing via ceramic point bearings. The helix as such can be made of an inert material, such as stainless steel or ceramics. Test carried out show that the helical centrifuge will reach a rotational speed of 12-16000 rpm quite simple.

Outgoing air through the outlet 15 is normally about 10°C above surrounding temperature, i.e., normally about 30°C.

Tests carried out have shown a very good degree of particle separation. Thus a device according to the above has been run in connection with a pellet driven wood heating furnace (villa furnace).

The results are evident from the following table.

Table

Relates to	Test 1[1)] Kl. 1154-1240	Test 2[2)] Kl. 1455-1529	Test 3[3)] Kl. 1540-1620
Amount of particles prior to cooling, mg/m^3 ntg	49	31	28
Amount of particles after cooling, mg/m^3 ntg	10	9	8
Separation degree %[4)]	80	71	71
pH	6,8	6,5	6,4
Suspending Substances, mg/l	65	63	45
Volume of condensate, ml	492	366	265-315

1) The determinations were carried out at normal wood heating. The effect withdrawal from the heating system was about 14.5 kW.
2) Determinations were carried out using an addition of water to the smoke gases in order to mimic wood heating using a fuel containing a higher moisture content than pellets.
3) Determinations were carried out as above with a further addition of water to the smoke gases.
4) The difference between the percentage degree of separation and 100% is rust being released from the metal in the equipment.

As evident from the table above a very high degree of particle elimination will be obtained.

As evident from FIG. 2 a substantial part of the particles present in the smoke gases from a pellet furnace a particle size of less than 1 μm, whereby a very substantial part has a particle size less than 0,2 μm, and in particular 0,1 μm and less. Here the equipment cannot determine particles less than 0,04 μm.

As evident from FIG. 3 the particles, after combustion and agglomeration have a particle distribution exceeding 6 μm, which can be simple separated off. FIG. 4 shows a non-agglomerated particle having a size of about 2 μm and FIG. 5 shows an agglomerated particle having a size exceeding 1 mm. It is apparent that a large particle can be easily caught and eliminated.

FIG. 6 and FIG. 7 show schematic embodiments of a particle collecting and eliminating device in an exhaust tube at a diesel engine (not shown). The device comprises a first chamber 1 having an inlet part 3, a gas permeable sock 38, which allows passage of substantially particle-free gas to a second chamber 2. In the end of the first chamber facing away from the inlet part 3 there is a brake plane 39 being arranged in the form of a wall being placed perpendicular to the gas flow presenting the exhaust pipe. In connection with this wall 39 there is heatable combustion surface/zone 6 arranged. The combustion zone is suitably heated by means of electricity obtained from a generator of an engine (not shown). Further, there is an outlet 41 being arranged in connection to the combustion zone 6 for continuous or intermittent of finally combusted particles in the combustion zone, which particles are suitably removed to a emptying container (not shown). In FIG. 6 the sock has the shape of a cone, while in FIG. 7 it takes the shape of a diametry plane. At the purification of diesel exhaust gases it shall be noted that the exhaust gases are pressed forward to the exhaust system using a fan (as different from

wood heating furnace example above, where a suction fan is placed on the outgoing side). By having a pressing fan the right velocities can be achieved in the exhaust pipe which will be further discussed below.

FIG. 8 shows a device wherein large particles are collected and/or are directly removed in a casing 43 which surrounds the combustion zone and where larger particles can be collected and/or be directly removed with the exhaust gases.

FIG. 9 shows the flow velocity around a device according to FIG. 8, whereby zone A relates to a velocity of about 20 m/s, while zone B denotes a velocity of about 30 m/s. In order to achieve that as many particles as possible reach the brake plane 39 the velocity in the chamber 1 should be as high as possible, i.e., in this case about 30 m/s.

FIG. 10 shows a device where the size of the opening around the apex of sock 38 can vary with temperature. At idling the temperature of the exhaust gases are low, as well as the velocity, why the size of the opening should be small to increase the velocity. Having an increasing engine temperature and engine load the velocity of the exhaust gases increase why the size of the opening can increase. This can be carried out by means of a bimetal regulated opening device 42 surrounding the apex of the sock 38. The opening device should, in this case, be designed with a number of blade parts overlapping each other to facilitate a small opening around the sock. If a device according to FIG. 7 is used, the throttling will have another physical design and can be made of one or two sheets creating a slot shaped opening.

Föreliggande anordning kan också användas för rening av luft, såsom ventilationsluft, varvid mikroskopiska partiklar, såsom allergener, bakterier och virus kan elimineras.

The present invention can also be used for cleaning of air, such as ventilation air, whereby microscopic particles, such as allergens, bacteria and virus can be eliminated.